Managing Growth in Wind Energy Production

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The Energy Information Agency predicts that in the next 25 years, wind energy capacity in the U.S. will grow by 300%. This paper will address some of the main issues affecting the growth in wind energy production in the U.S. and Michigan including regulatory issues, environmental concerns, and technological barriers. In keeping with a local environmental planning context, most of the focus will be on environmental concerns, including concerns over public safety and welfare, with many references to local policies and regulations. A discussion of wind energy production is certainly apropos as policy-makers are recognizing the problems associated with current methods of energy production.

Worldwide patterns of energy consumption are leading towards an ecological catastrophe in the form of global climate change. According to the International Energy Agency, in the year 2000 79.4 percent of total worldwide primary energy supply came from fossil fuels that emit greenhouse gases (GHG) (International Energy Agency 2002). In contrast, only 13.8 percent of total primary energy came from renewable sources (the remaining 6.8 percent came from nuclear power), and of that the vast majority was from hydropower, combustible renewables, and wastes in periphery and semi-periphery nations. Only 0.065 percent came from solar and wind. In the U.S. the percentage of energy from renewable sources was just 6 percent as of 2004, with only 0.18 percent of total energy coming from solar and wind (Energy Information Administration 2003). The greatest challenge in the coming decades will be reducing our overall energy consumption and shifting to an energy source, such as wind, that does not emit GHGs.

Modern California windmills. Photo: Krista Trout-Edwards

The Energy Information Agency predicts that in the next 25 years, wind energy capacity in the U.S. will grow threefold, bringing it to about 12,000 megawatts (MW) (Johnson 2003). This paper will address some of the main issues affecting the growth in wind energy production in the U.S. and Michigan including regulatory issues, environmental concerns, and technological barriers. It will look at strategies for eliminating barriers to wind production across these issues at all levels of government, and will analyze case studies of successful wind energy production in the U.S. In keeping with a local environmental planning context, most of the focus will be on environmental concerns, including concerns over public safety and welfare, with many references to local policies and regulations. A key resource specific to Michigan concerning local ordinances is the "Wind Siting Guidelines for Wind Energy Systems Draft Report" developed by the Michigan Energy Office in the Department of Labor and Economic Growth (DLEG). According to the report, these guidelines are meant "to help local officials strike a balance between the need for clean, renewable energy resources and a local government's responsibility to protect the public health, safety and welfare" (Klepinger 2007).

The paper will also address the trade-offs associated with onshore and offshore wind development in relation to the aforementioned issues. A discussion of off-shore wind production is especially pertinent to Michigan, which boasts the potential for 44,000 MW of offshore wind generating capacity according to the National Renewable

Energy Laboratory. As a comparison, current power generation capacity from all sources in Michigan is 29,000 MW (Energy Information Administration 2003). The paper will begin with a short overview of wind energy technology and its limitations, then analyze environmental problems and benefits related to wind production, and offer suggestions for regulatory solutions at all levels of government. It will conclude with a presentation of pertinent case studies.

Technological Barriers to Wind Production

The basic operation of wind turbine generators (WTG) is simple – wind spins the blades, which spin a shaft, which connects to a generator that produces electricity. At this point in time, power production from wind is limited in relation to fossil or nuclear fuels since a single nuclear power plant can still generate more power than the world's four largest wind farms combined (Johnson 2003). The key technological difficulties related to wind energy production include scattered resource availability, difficulty in energy storage, turbine production, and electricity transmission.

Scattered resource availability is a problem since energy production from wind is dependent on when the wind is blowing, and this does not necessarily coincide with energy demand. Currently, there are no reliable or efficient ways of storing large amounts of energy for later use, so electricity coming from wind needs to be consumed concurrent with generation. Due to this, many argue that wind is not a reliable baseload power source like coal or nuclear power. As such, increases in wind production will tend to offset lower-emissions intermediate fuel sources such as natural gas and petroleum unless wind energy can be complemented by other renewable sources such as solar and more constant sources such as geothermal heat or cellulosic biomass.


Windmill in the French Provenal region. Photo: Sarah Elizabeth Ross

One way of solving the storage problem is by using the energy generated from wind to pump water to higher elevations, like a dam reservoir, in effect creating potential energy that can be used later when the water is released. Another method targeted at increasing financial potential regardless of resource availability is through "net metering," a scheme used by on-site producers of wind energy whereby, according to the American Wind Energy Association, "excess electricity produced by the wind turbine will spin the existing home or business electricity meter backwards, effectively banking the electricity until it is needed by the customer" (2007).

Another technological problem associated with wind energy production is turbine manufacturing and electricity transmission from these turbines. Power production from wind is directly dependent on the size of the turbine, which can cause conflicts with surrounding land uses. This conflict can be partly overcome by moving wind farms offshore and increasing turbine size, since offshore turbines have lower material transportation costs, allowing for larger construction projects. This movement offshore will also help overcome the problem of high transmission costs, which are inherent with any renewable energy technology based on immobile fuel sources. Offshore production can alleviate transmission problems since many population centers are located along the coast and serve as easy grid connection points. For instance, consider that about 26 million people live in coastal counties bordering the Great Lakes (National Oceanic and Atmospheric Administration 2007). However, there are still problems with onshore transmission since wind resources are often abundant in rural areas, which lack adequate transmission infrastructure. Federal energy corridors can help overcome transmission problems in some of these areas by siting the corridors along areas with high wind resources, and allowing WTGs access to the grid.

Environmental Concerns for Wind Energy Production

In addition to technical issues, some are concerned that energy production from wind will have negative impacts on the local environment. While issues such as dead birds, noise, marine impact, and aesthetic issues in regards to panorama disruption all contribute to the environmental impacts associated with wind energy production, many of these impacts can be mitigated through the use of proper local zoning and planning techniques based on project size and location.

Opponents of wind energy production commonly refer to bird fatalities from spinning turbines, which are mainly caused by collision with rotating blades and electrocution from transmission lines. In addition, WTGs have the potential to alter migration routes, reduce habitat, and disturb breeding, nesting, and foraging (Hohmeyer, Wetzig, and Mora 2004). The issue came to the forefront during the Altamont Pass wind farm project in the late 1980s and early 1990s, when 6,000 turbines were installed on 70 square miles of rolling hills east of San Francisco. During four years of operation, radio-tagged golden eagles, red-tailed hawks and kestrels were killed by wind turbines either due to collision with blades or electrocution from power lines (Johnson 2003). One should note for purposes of comparison that in 2005, an estimated 75 to 100 million birds were killed by house cats, 10 to 60 million by vehicle collisions, and 100 to 500 million by collisions with buildings and structures. By contrast, only 20 to 30 thousand birds were killed by interaction with wind power developments and this number is expected to increase to only 80 to 120 thousand by 2020 (Klepinger 2007).

A major concern of groups like the Audubon Society is the placement of large wind farms along bird migratory paths. While it will not be possible to avoid 100 percent of bird fatalities by wind turbines, Kerns and Kerlinger suggest that "proposals for new wind farms that consider bird migration routes, bird abundance and turbine height will help to minimize fatalities" (Kerns and Kerlinger 2004, 24). In addition, fatalities can be reduced by avoiding specific microhabitats, using appropriate tower design (tubular or lattice), using slower-moving blades, illuminating blade tips, and routing electrical lines underground, as well as by creating local regulations that require an avian impact analysis for any proposal (Hohmeyer, Wetzig, and Mora 2004).

Although caution in siting wind farms can avoid many problems with avian wildlife, development of off-shore wind production may result in impact to the surrounding aquatic community. Specific impacts to marine life include the effects of electromagnetic fields generated by turbines and underwater cables, noise from installation and electricity generation, and habitat degradation or fragmentation. "[Marine biologists are concerned that electromagnetic fields near the generators and cables might disrupt navigation of some fish and mammalian species that use the earth's magnetic field for navigation." (Pryor, Shahinian, and Stout 2005, 17). This is of special concern where navigation to breeding grounds is involved. Besides electromagnetic disruption, noise could disrupt or displace marine life sensitive to low-frequency sounds produced during power generation. Another concern is the impact on traveling or feeding fish and marine habitat from foundations of very large wind farms, which could act as an obstacle, as well as how transmission cables are laid or buried (Pryor, Shahinian, and Stout 2005, 18).

A recent report released in Denmark assessed the environmental impacts of offshore wind farms and found that waterbird collision is rare, abundance and biomass of benthic communities increased at the wind farm sites, and effects of electromagnetic fields varied by fish—some were attracted to the fields, while others avoided them. In an article about the Denmark study, Jack Coleman notes that one site experienced a slight decrease in porpoise activity, which slowly began to increase after initial construction (2006). Overall, the report suggested that offshore wind development creates little harm to the marine community, especially past the construction phase. Currently, the environmental effects of offshore wind production are not well understood, but may decrease as the farm moves further from shore, where aquatic life is less dense.

In addition, the further the wind farm is placed offshore, the less visual impact it will have. Visual impact is another potential barrier for constructing wind turbines, and one that may be opposed by nearby residents of a proposed wind farm. According to a report issued by the European Wind Energy Association, "visual impact (from WTGs) has a direct effect on…a landscape. A landscape attracts different perceptions since aesthetic values such as beauty and diversity are subjective, while its value will also be influenced by use (e.g. national park, wildlife habitat, agricultural land)." (Hohmeyer, Wetzig, and Mora 2004, 179). As such, citizen participation and public buy-in will be important in alleviating concerns over visual impact. Dan Albano of Global Winds Harvest Inc. says that "concern about visual impact is the biggest hurdle to using wind power in some locations and that resistance has hardened in places where people have summer homes." (Homsy 2007, 48). A prime example of this resistance is embodied in the "Alliance to Protect Nantucket Sound," a citizen group in Cape Cod that is opposed to the development of an offshore wind farm in Nantucket Sound based on aesthetic issues and reduction of visual amenity.

Author Paul Gipe suggests the following aesthetic guidelines for wind farms to reduce visual impact and increase public acceptance: ensure visual uniformity (direction of rotation, type of turbine, and tower height); avoid fencing; minimize or eliminate roads; bury intraproject power lines; limit or remove ancillary structures from the site; remove inoperative turbines; avoid steep slopes; control erosion and promptly revegetate; remove litter and scrap; and clean dirty turbines and towers (Gipe 1995). One possibility of reducing aesthetic problems is the reuse of industrial sites, pending availability of wind resource. Again, local zoning regulations concerning siting of WTGs will be an important part in alleviating concern over visual impact. These ordinances should require a visual impact statement, including a visual simulation of the proposed development.

Another component of aesthetic impact is shadow flicker, which occurs when rotating blades interfere with the sun's rays and cause a flickering effect due to the shadows of rotating blades. This is of particular concern as it affects sun shining directly into nearby residences. The only regulation to date concerning shadow flicker was enacted in Germany, where a court ruled that the maximum allowable flicker would be 30 hours per year (Klepinger 2007). A technical strategy for alleviating shadow flicker involves installing programs that cause turbines to shut down when conditions make shadow flicker likely.

In addition to concerns over visual impact, noise from wind turbines comes from the spinning blades, the generator, the gearbox, and the hydraulic system (however, with advances in technology the hydraulic system is now virtually silent) (Klepinger 2007). The impact this noise has on the surrounding community depends on adjacent land uses, ambient conditions, and urban/rural characteristics. Noise from large wind turbines (greater than 1 MW) can approach moderate levels (less than 50 dBA) at 200 to 300 meters from the source depending on surrounding ambient conditions and turbine type. As a comparison a quiet room is 40dBA and a normal conversation 3 feet away is 60dBA (Canadian Center for Occupational Health and Safety 2007). Importantly, adding another turbine of the same power level only increases sound pressure by roughly three dBA, so clustering of turbines will have advantages in concentrating noise level (Hohmeyer, Wetzig, and Mora 2004).

Distance from noise plays an important role in perceived sound level, and as such siting guidelines suggest noise level from WTGs should not exceed 55 dBA at the property line unless the ambient sound pressure level exceeds 55 dBA, in which case the guideline should be the ambient level plus 5 dBA (Department of Labor and Economic Growth 2007). The guidelines suggest that for Utility Grid systems, this sound pressure level cannot be exceeded for more than 3 minutes in any hour of the day, and the applicant should provide modeling of the system prior to installation to confirm that the system will not exceed maximum sound pressure levels. These are only guidelines for localities, based on EPA and World Health Organization reports of noise effects on public health, so communities should modify these levels depending on individual circumstance.

Regulatory Issues

While concerns over aesthetic and environmental impact can primarily be addressed at the local level, federal and state governments play key roles in encouraging wind energy production. One of the most effective federal policies to encourage wind energy production would be a national renewable portfolio standard, which would mandate that a certain portion of energy production come from renewable sources. For example, the house version of the recently proposed energy bill would require 25 percent of the nation's electricity to come from renewable sources by 2025 (Lacey 2007). In addition, federal tax credits to producers of renewable energy would help make renewable energy production more competitive. Ultimately, power generated from fossil fuel sources is drastically under-priced, with current costs failing to reflect the impact these fuels have on climate change and human health. Thus, any regulation that sends price signals based on true social cost (such as a cap-and-trade system or carbon tax) would place renewable energy on an equal playing field with fossil fuels, resulting in increased financial feasibility.

States are currently taking the lead in promoting clean energy. Indeed, one school of thought is that federal mandates are unnecessary – if states lead the way, the federal government will follow. At this point, 20 states and Washington D.C. have enacted state-wide renewable portfolio standards. Michigan has yet to follow, but according to a recent article by Eric Morath, Governor Jennifer Granholm recently called for a mandate that 25 percent of power come from renewable sources by 2025 (2007). States can also play a key role in financing energy initiatives, with the bulk of grants and financial assistance coming from state government.

While often overlooked by an industry that is spatially ubiquitous and seldom associated with concerted local effort, local governments do have a strong role to play in promoting renewable energy. Many localities have set their own renewable portfolio standards. For example, Ann Arbor recently implemented an "energy challenge," which calls for municipal operations to use 30 percent renewable energy by 2010, and this "extends to the entire city" by 2015. As part of Ann Arbor's energy plan, the city is looking into purchasing "locally-grown" electricity from wind. According to the City's website, they are "partnering with Washtenaw County and others on the Washtenaw Wind Project, an effort to evaluate and encourage wind development in the county." (City of Ann Arbor 2007).

In addition to passing ordinances encouraging renewable energy production, localities will also need to ensure land use compatibility. The installation of WTGs may conflict with surrounding land uses depending on the rural character of the installation site. Since only 1 percent to 3 percent of total area required for wind production is dedicated to the turbine—the remaining land being required for proper turbine spacing—wind farms are typically well-situated to rural areas and farmland (Hohmeyer, Wetzig, and Mora 2004). Farmers can still use 99 percent of the land for growing crops, and the space occupied by the turbines will likely be the most profitable land on the farm. One way that local governments can alleviate concerns over land use conflict is through the use of adequate setback requirements, which address issues of safety such as equipment failure (collapse) and ice throw from turbine blades. As such, the DLEG guidelines suggest mandating a setback at least equal to the vertical height of the tower in case of tower collapse or ice fall from non-spinning blades. While few Michigan communities currently have wind siting laws, the DLEG suggests that those that "proactively plan for wind turbines and carefully develop regulations for their installation will avoid a measure of uncertainty and the unfortunate public discord that sometimes comes along with new land use proposals" (Department of Labor and Economic Growth 2007).

Case Studies

The paper will now describe two examples of successful developments in wind energy production. In Mackinaw City, Michigan, one of the few examples from the state, the village converted an unused industrial area to a center for renewable energy production. Madison County, New York, serves as an example for local governments in responding to the concerns of surrounding residents and highlights the compatibility of wind turbines with agricultural land uses.

Mackinaw City, MI

Mackinaw City is a village in Northern Michigan at the southern end of the Mackinaw Bridge. In 2006, the population was 856 people. The urban area is 3.36 square miles with a population density of 256 people per square mile. In 2000, the city was trying to figure out what to do with unused sewer spray fields in an industrial area near the city center. Mackinaw City has high wind resources due to strong currents coming off Lake Huron and the Mackinaw Straits, so the city studied the feasibility of installing wind turbines on the former spray fields.

In 2001, the city worked with Bay Windpower to work out a lease and power purchase agreement (a long-term agreement to buy power from a company that produces electricity). These agreements would provide all municipally-owned buildings with power at a set rate and provide the Village with income from a lease arrangement for the land. The company built two 900 kilowatt turbines, which power about 600 homes per year. According to the City's website, "in their first 4 days of operation [the turbines] produced enough energy to power 9 homes for a year. As of the fall of 2003 they had produced over 4,000 MWh of energy" (Village of Mackinaw City 2007).

Citizen support for the project has been very strong. According to the city website, the project "has received many positive comments from residents and visitors alike. The residents voice their pride in being part of such a project that brings renewable energy to the region and the visitors are impressed with the way [the turbines] look. Some go so far as to call them kinetic sculptures." (Village of Mackinaw City 2007). This public support was crucial, as citizen concern can often stymie a project.

The city enacted a zoning provision to expressly allow wind power generation and the erection of wind turbine generators. The ordinance places WTGs in a special use category due to the fact that the structures are large, the technology is new, and uncertainty exists about project success. Section 23-132 of the city zoning ordinance specifically permits WTG usage in the Sewer Plant District, but does not leave room for future turbine installation elsewhere. Site setbacks must equal half the height of the vertical tower and blade, which is less than the amount recommended by the DLEG's guidelines. The sound pressure level cannot exceed 60 dBA at the property line, and the applicant must provide certification of meeting this requirement before and after construction. However, the ordinance does not make any concession when ambient sound pressure exceeds 60 dBA. The minimum required site area is 20 acres, but each WTG must have at least 5 acres of site area (Village of Mackinaw City 2007).

Madison County, NY

Madison County in upstate New York is 656 square miles and has a population of 70,200 people. In November 2001, Atlantic Renewable Energy built a 30 MW project on 12 acres of private rural farmland near the small town of Fenner, 26 miles east of Syracuse. The project comprises twenty 1.5 MW turbines, all rising 213 feet above the ground.

The project developer leased private land from local landowners to construct the turbines, which use only 1.5 percent of the leased land so farmers can still use the land for livestock grazing and agricultural cultivation all the way up to the base of the turbine. The New York State Energy Research and Development Authority, a statewide program, originally issued a request for proposals to build a wind energy facility in the area, and Atlantic Renewable Energy was awarded a $5 million contract for the project. The RFP was in part motivated by a statewide renewable portfolio standard.

A key aspect of the project's success was the developer's work with the local community throughout the permitting process. The developer adhered to a full-disclosure policy and performed community outreach and education. Specifically, the developer described how wind energy facilities work, demonstrated what the site would look like (e.g., by using simulated pictures), and generally addressed local community concerns and questions. Currently, the level of community acceptance is high.

The environmental assessment also helped to alleviate citizen concern as well as demonstrate the project's low environmental impact. The assessment included an avian impact study, an analysis of agricultural protection measures, a cultural resources assessment, a noise simulation, and a visual impact assessment. As part of the visual impact assessment, the developer placed large weather balloons that approximated tower location and superimposed images of the turbines on photographs of the site. As demonstrated by case study interviews, many respondents noted that they much preferred the turbines to cell phone towers. Unfortunately, at this time issues of shadow flicker are unresolved.

Authorities used a wind overlay district to overcome the town's height restrictions, and settled on accepting payment in lieu of taxes. The original proposal was to develop the project in two phases, with half the turbines being constructed first, followed later by the remaining half. However, the two phases eventually became one as other landowners not originally consulted became interested in leasing their land. As such, the developer spread turbines around to more properties than originally expected. The County and Town expressed concern over road conditions as a nearby wind farm reportedly had negative impacts on the surrounding roads and the developer offered to repair and replace roads as necessary (National Wind Coordinating Committee 2005).

Conclusions

It should be clear that investment and growth in the U.S. renewable energy sector are essential to long-term ecological and economic stability. Specifically, Michigan has huge potential for onshore and offshore wind energy development, which can help to strengthen the state economy while providing clean energy. Positive developments are currently taking place around the country, so it will be the responsibility of developers and policymakers at all levels of government to support this growth. Investment costs for wind energy production are expected to continue to decrease as improvements in technological efficiency take place. Indeed, investment costs per swept rotor area have declined by around three percent per annum in the last twelve years for an overall reduction of around 30 percent (Poul and Chandler 2004). As these investment costs decrease, proposals for wind energy production will increase, and thus local policymakers should act now to ensure that this growth is well-planned and minimizes the impact on the surrounding environment.

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